Remarks/Arguments

Claims 35-44, 46, 47, 50 and 51 are pending in the Application.

Claims 35-44, 46, 47, 50, and 51 stand rejected.

I. INCORPORATED BY REFERENCE MATERIAL

Examiner has objected to the specification because "Applicant is required to amend the disclosure to include the material incorporated by reference, if the material is relied upon to overcome any objection, rejection, or other requirement imposed by the Office." Office Action, at 2. In particular, the Examiner has noted the Specification of the present Application incorporates by reference M.S. Dresselhaus, G. Dresselhaus, and P.C. Eklund, *Science of Fullerenes and Carbon Nanotubes*, Chap. 19, especially pp. 756 760, (1996), published by Academic Press, 525 B Street, Suite 1900, San Diego, California 92101 4495 or 6277 Sea Harbor Drive, Orlando, Florida 32877 (ISBN 0-12-221820-5) ("*Dresselhaus*"), to provide support for the particular nomenclature used.

As an initial point, Applicant notes that the Specification, as originally filed stated:

> In defining carbon nanotubes, it is helpful to use a recognized system of nomenclature. In this application, the carbon nanotube nomenclature described by [*Dresselhaus*], which is hereby incorporated by reference, will be used.

Application at 6, *ll.* 8-14. Thus, as explained in the Specification, the nomenclature utilized therein is a recognized system in the art, and, therefore, a person of ordinary skill in the art would readily understand the nomenclature system of *Dresselhaus* utilized in the Application. Accordingly, Applicant traverses Examiner's position that *Dresselhaus* is "essential material" as defined by 37 C.F.R. § 1.57(c).

However, to facilitate prosecution, Applicant has amended the Specification to state as follows:

> In defining carbon nanotubes, it is helpful to use a recognized system of nomenclature. In this application, the carbon nanotube nomenclature described by M.S. Dresselhaus, G. Dresselhaus, and P.C. Eklund, *Science of Fullerenes and Carbon Nanotubes*, Chap. 19, especially pp. 756-760, (1996), published by Academic Press, 525 B Street, Suite 1900, San Diego, California 92101-4495 or 6277 Sea Harbor Drive, Orlando, Florida 32877 (ISBN 0-12-221820-5), which is hereby incorporated by reference, will be used. <u>The single wall tubular fullerenes are distinguished from each other by double index (n,m) where n and m are integers that describe how to cut a single strip of hexagonal "chicken-wire" graphite so that its edges join seamlessly when it is wrapped onto the surface of a cylinder.</u> The dual laser pulse feature described herein produces an abundance of (10,10) single-wall carbon nanotubes. The (10, 10) tubes are known as "armchair" tubes. <u>When the two indices are the same, m=n, the resultant tube is said to be of the "arm-chair" (or n,n) type, since when the tube is cut perpendicular to the tube axis, only the sides of the hexagons are exposed and their pattern around the periphery of the tube edge resembles the arm and seat of an arm chair repeated n times.</u> All armchair tubes are metallic. Other armchair tubes are denoted as (n, n) where n is an integer from 1 to infinity, preferably 1 to 1000 more preferably 5 to 500. The (10,10), single-wall carbon nanotubes have an approximate tube diameter of 13.8 Å ± 0.3 Å or 13.8 Å ± 0.2 Å.

The included sentences being inserted herein are contained within the materials previously incorporated by reference, and these amendments contain no new matter.

In light of the above, the Applicant respectfully requests that the Examiner withdraw her objection to the specification.

II. <u>REJECTIONS UNDER 35 U.S.C. § 112, ¶ 1</u>

Examiner has rejected Claims 35-44, 46-47 and 50-51 under 35 U.S.C. § 112, ¶ 1, as failing to comply with the written description requirement. Office Action, at 2. The Examiner contends that "[t]he claims(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. The claims recite that they are (10,10) carbon nanotubes, but the specification incorporates the

essential subject matter necessary to understand this limitation by reference to a publication. Therefore, the specification does not describe the claimed subject matter." Office Action, at 2-3.

Applicant traverses this amendment. As stated in Section I, and as explained in the Specification, the nomenclature utilized in the present Application is a recognized system in the art, and, therefore, a person of ordinary skill in the art of the art would readily understand the nomenclature system of *Dresselhaus* utilized in the Application. As such, a person of ordinary skill in the art would know what a (10,10) carbon nanotube was. Hence, Applicant has described the subject matter in such a way as to reasonably convey to one skilled in the relevant art that the inventors, at the time the application was filed, had possession of the claimed invention.

Nevertheless, and again to facilitate prosecution, Applicant has amended the specification to incorporate subject matter from *Dresselhaus*. The materials inserted herein are materials previously incorporated by reference and the amendments contain no new matter.

In light of the foregoing amendment, the Applicant respectfully requests that the Examiner withdraw the rejection of Claims 35-44, 46-47 and 50-51 under 35 U.S.C. § 112, ¶ 1.

III. REJECTIONS UNDER 35 U.S.C. § 103(a) OVER *AJAYAN* IN VIEW OF *CURL*

Examiner has rejected Claims 35-44, 46-47 and 50-51 under 35 U.S.C. § 103(a) as obvious over Ajayan, *et al.*, "Growth morphologies during cobalt-catalyzed single-shell carbon nanotube synthesis" *Chemical Physics Letters,* Vol. 215, No. 5, Dec. 10, 1993, pp. 509-517 ("*Ajayan*") in view of Curl, R. F., "Collapse and Growth" *Nature*, May 6, 1993, 353, pp. 14-15 ("*Curl*"). Office Action, at 3.

Applicant respectfully traverses the rejections.

The following tenants of patent law must be adhered to when analyzing obviousness under 35 U.S.C. § 103:

(A) The claimed invention must be considered as a whole;

(B) The references must be considered as a whole and must suggest the desirability and thus the obviousness of making the combination;

(C) The references must be viewed without the benefit of impermissible hindsight vision afforded by the claimed invention; and

(D) Reasonable expectation of success is the standard with which obviousness is determined.

M.P.E.P. § 2141(II); *Hodosh v. Block Drug Co.*, 786 F.2d 1136, 1143 n.5, 229 U.S.P.Q. 182, 187 n.5 (Fed. Cir. 1986).

Therefore, among other things, to establish a *prima facie* case of obviousness under §103(a), the prior art reference (or references when combined) must teach or suggest all the claim limitations and there must be a reasonable expectation of success regarding the claimed combination. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art and not based on applicant's disclosure. *See* M.P.E.P. 706.02(j); *see also In re Vaeck,* 947 F.2d 488, 20 U.S.P.Q.2d 1438 (Fed. Cir. 1991).

Even if a *prima facie* case of obviousness is established, that does not end the obviousness analysis. Rather, the burden then shifts to applicant, who may then present objective evidence (*i.e.*, unexpected results, praise of the invention, *etc.*) to support the non-obviousness of the claimed invention. Such objective evidence is generally the most probative evidence of non-obviousness. *Custom Accessories Inc. v. Jeffery-Allan Industries Inc.*, 807 F.2d 955, 1 USPQ.2d 1196(Fed. Cir. 1986). Applicant respectfully reminds the Examiner that, when objective evidence of nonobviousness is presented, this evidence must be considered. *In re Sernaker*, 702 F.2d 989, 996, 217 U.S.P.Q. 1, 7 (Fed. Cir. 1983).

The reasons for this procedure is to preclude the use of hindsight, which is not permitted in § 103 analyses. "One cannot use hindsight reconstruction to pick and choose among isolated disclosures in the prior art to deprecate the claimed invention." *In re Fine*, 837 F.2d 1071, 5 U.S.P.Q.2d 1596, 1600 (Fed. Cir. 1988). Moreover, such evidence "serve[s] as insurance against the insidious attraction of the siren hindsight" when evaluating the prior art. *W.L. Gore & Assoc. v. Garlock, Inc.*, 721 F.2d 1540, 1553, 200 U.S.P.Q. 303, 313 (Fed. Cir. 1983).

A. *Ajayan* and *Curl* do not separately or in combination teach or suggest the claim limitations for each of the claims

Regarding Claim 35, this independent claim requires a rope of single-wall carbon nanotubes having 50 to 5000 single-wall carbon nanotubes of which greater than 10% are (10,10) single-wall carbon nanotubes.

Examiner contends that *Ajayan* "discloses a material which comprises all single wall carbon nanotubes wherein the nanotubes are in the form of web and/or strings which correspond to the claimed felt/mat and rope." Office Action, at 4. Examiner states that *Ajayan* "does not disclose the claimed number of nanotubes in the rope or the basis weight of the claimed felt." *Id.* Examiner further states that *Ajayan* "differs from the claimed invention because it does not disclose that the nanotubes at [*sic*, are] 10,10 nanotubes." *Id.*

The Examiner has asserted that "it would have been obvious to have formed the nanotubes taught by *Ajayan*, motivated by the method of laser vaporization taught by *Curl*, motivated by the expectation that this would produce high yields." *Id.* However, nowhere in *Curl* does it teach or suggest (10, 10) carbon nanotubes. In fact, *Curl*'s teachings are not directed to single-wall carbon nanotubes, but rather a "buckminsterfullerene," also known as C_{60}, which is a spherical molecule of 60 carbons arranged in hexagons and pentagons.

Thus, there is no teaching or suggestion in *Ajayan* or *Curl* for making a rope of single-wall carbon nanotubes having 50 to 5000 single-wall carbon nanotubes of which "greater than 10% are (10,10) single-wall carbon nanotubes." Consequently, all of the limitations of the claimed invention of Claim 35 are not taught or suggested in *Ajayan* and *Curl*, separately or in combination.

Regarding Claims 36-44, these claims are dependent directly or indirectly upon independent Claim 35. As such, all of the limitations of the claimed invention of each of these dependent claims are not taught or suggested in *Ajayan* and *Curl*, separately or in combination.

Regarding Claim 46, this claim requires a felt of single-wall carbon nanotubes, wherein said felt is electrically conductive, as well as all of the requirements of Claim 35, *i.e.* the single-

wall carbon nanotubes comprise ropes of single-wall nanotubes, wherein greater than 10% of the single-wall carbon nanotubes are (10, 10) single-wall carbon nanotubes. Furthermore, neither *Ajayan* nor *Curl* teaches or suggests a felt of single-wall carbon nanotubes. Consequently, all of the limitations of the claimed invention of Claim 46 are not taught or suggested in *Ajayan* and *Curl*, separately or in combination.

Regarding Claims 47 and 50-51, these claims are dependent directly upon Claim 46. As such, all of the limitations of the claimed invention of each of these dependent claims are not taught or suggested in *Ajayan* and *Curl*, separately or in combination.

For this reason alone, the *prima facie* case of obviousness has not been established for any of the pending claims and therefore Claims 35-44, 46-47 and 50-51 are not obvious over *Ajayan* in view of *Curl*.

B. There was no reasonable expectation of success regarding the claimed invention

Because *Ajayan* and *Curl* do not disclose all of the limitations for any the claims, the Examiner attempts to bridge this gap by contending that "[o]nce the laser vaporization method was employed, the (10,10) carbon nanotubes would necessarily be present as the predominant nanotubes." (Office Action, at 4). Interestingly, the basis for this statement by Examiner is because "[t]he Specification teaches that laser vaporization produces predominantly single-wall (10,10) nanotubes." This analysis is flawed.

First, the Examiner has used the present Application as the roadmap to explain how the carbon nanotube ropes, as specified in the claims, were obvious to make. Using the Application for such purpose is impermissible in an obviousness analysis. *See* M.P.E.P. 706.02(j).

Furthermore, at the time of the invention, there was no reason whatsoever to expect that a rope of single-wall carbon nanotubes having the limitations of the pending claims (including having greater than 10% (10,10) single-wall carbon nanotubes) would have resulted from a laser vaporization method.

Moreover, the Examiner's analysis appears to trivialize the significance of the pioneering

work that was done by Applicant to discover a laser vaporization technique to produce carbon nanotubes. Reasonable expectation must be made at the time the invention was made. M.P.E.P. § 2143.02. As discussed in more detail in sub-section (C) below, it was a noteworthy and well documented event when Applicant successfully made single-wall carbon nanotubes using a laser vaporization technique. It is dubious that this would have been the case had there been a reasonably expectation of success regarding the claimed invention at the time of Applicant's work.

Again, for this reason, the *prima facie* case of obviousness has not been established for any of the pending claims and therefore Claims 35-44, 46-47 and 50-51 are not obvious over *Ajayan* in view of *Curl*.

C. The objective evidence reveals that the claimed invention is non-obvious

As noted above, objective evidence is generally the most probative evidence of non-obviousness. *Custom Accessories Inc. v. Jeffery-Allan Industries Inc.*, 807 F.2d 955, 1 USPQ.2d 1196(Fed. Cir. 1986). Objective evidence of non-obviousness includes unexpected results, praising of the invention, *etc.*. M.P.E.P. § 716.01(a).

Applicant has submitted herewith a 37 C.F.R. § 1.132 Declaration of Ken Smith, Ph.D., dated December 15, 2006, (the "Smith 132 Declaration") evidencing the non-obviousness of the claimed invention.

1. Applicant's Invention Was Unexpected

The presence of a property not possessed by the prior art is evidence of nonobviousness. *In re Papesch*, 315 F.2d 381, 137 U.S.P.Q. 43 (C.C.P.A. 1963); *Ex parte Thumm*, 132 U.S.P.Q. 66 (Bd. App. 1961). Likewise a "greater than expected result is an evidentiary factor pertinent to the legal conclusion of obviousness ... of the claims at issue." *In re Corkill*, 711 F.2d 1496, 226 U.S.P.Q. 1005 (Fed. Cir. 1985); M.P.E.P. § 716.02(a). As reflected in the Application, the Applicant was able to produce carbon nanotube ropes of single-wall carbon nanotubes having 50 to 5000 single wall carbon nanotubes of which greater than 10% are (10, 10) single wall carbon

nanotubes. This was totally unexpected; in fact, this discovery was considered a major breakthrough in the field of nanotechnology.

As evidence of this, Applicant has attached hereto a paper written by Dr. M.S. Dresselhaus, Professor at the Massachusetts Institute of Technology, Department of Electrical Engineering and Computer Science and Department of Physics. Dr. Dresselhaus is, in fact, one of the co-authors of *Dresselhaus* referred to above and is the co-developer of the (n,m) nomenclature for carbon nanotubes. In this paper, Dr. Dresselhaus states:

> Most of the presently used single-wall carbon nanotubes have been synthesized by a pulsed laser vaporization method, pioneered by the Smalley group at Rice University. ***Their synthesis result of 1996 represents a major breakthrough in the field.***...There are presently many groups worldwide working to develop more efficient synthesis techniques for producing arrays of similar single-wall carbon nanotubes, with a narrow diameter and chirality distribution, at a high production rate, and at a cheap cost. ***Right now, it is possible through Smalley's recent work to produce significant amounts of (10,10) armchair nanotubes with a small average diameter (~1.3 nm) and a small diameter distribution.*** Much effort is presently being expended to develop production methods to provide controlled synthesis of nanotube arrays of different chiralities. ***This field is very new, and many groups are now trying to reproduce the sample quality achieved by the Rice group.***

M.S. Dresselhaus, "Carbon-Based Nanostructures" (January 1998). Ex. 1, attached to the Smith 132 Declaration, at 2. The World Technology Evaluation Center[1] Report on "R&D Status and Trends in Nanoparticles, Nanostructures Materials, and Nanodevices in the United States," May 8-9, 1997 Workshop repeated exactly the same. Ex. 2, attached to the Smith 132 Declaration, at 5.

The pulsed laser vaporization method pioneered by the Smalley group at Rice University is precisely the work that is disclosed and taught in the present Application. Applicant notes that

[1] The World Technology Evaluation Center is sponsored by the National Science Foundation, the Air Force Office of Scientific Research, the Office of Naval Research, the Department of Commerce (including NIST and Technology Administration, Main Commerce), the Department of Energy, the National Institutes of Health, and the National Aeronautics and Space Administration of the United States Government. Smith Declaration, Ex. 2, at 2.

Dr. Richard E. Smalley and Rice University are, respectively, the first named inventor and the assignee of the present Application.

The importance of the present invention and its unexpected results is further demonstrated by the repeated identification and recognition of Applicant's discovery for producing carbon nanotubes by the laser vaporization technique. As representative examples, it has been reported:[2]

(1) "In 1995, Smalley's group at Rice University reported the synthesis of carbon nanotubes by laser vaporization." *The Wondrous World of Carbon Nanotubes, a review of current carbon nanotube technologies*, Eindhoven University of Technology, (27 February 2003), at p. 14 (Ex. 3, attached to the Smith 132 Declaration, at 2). This report further provided a short summary "of the three most common techniques used nowadays [*i.e.*, in 2003]" to produce carbon nanotubes and again identified Dr. Smalley's group at Rice University as the creator of the laser vaporization technique. *Id.* at 23 (Ex. 3, attached to the Smith 132 Declaration, at 3).

(2) "Since the first demonstration in 1995 of the use of a Q-switch Nd:YAG laser as a new alternative to synthesize single-wall carbon nanotubes [by the Smalley group at Rice University], the field of laser synthesis of carbon nanotubes continues to attract great interest for either fundamental or applications purposes." N. Braidy, *et al.*, "Single-Wall Carbon Nanotubes Synthesis by Means of UV Laser Vaporization: Effects of the Furnace Temperature and the Laser Intensity Processing Parameters," *Mat. Res. Soc. Symp. Proc.*, Vol. 703, V9.31.1 & V9.31.6 (2002) (Ex. 4, attached to the Smith 132 Declaration, at 1 & 6).

(3) "When the Rice University group found a relatively efficient way to produce bundles of ordered single-wall carbon nanotubes in 1996, it opened new opportunities for

[2] Applicant's also note that the Encyclopaedia Britannica's Guide to the Nobel Prizes states with regard to fullerenes: "In 1996 a group led by Smalley produced SWNTs in high purity by laser vaporization of carbon impregnated with cobalt and nickel." A true and correct copy of the excerpt from Encyclopaedia Britannica's Guide to the Nobel Prizes respecting fullerenes, as printed out from the Internet on or around December 14, 2006, is attached as Attachment A, hereto.

quantitative experimental studies on carbon nanotubes. These ordered nanotubes are prepared by the laser vaporization of a carbon target…." "Carbon Nanotubes," *physicsweb*, Institute of Physics Publishing (January 1998) (Ex. 5, attached to the Smith 132 Declaration, at 3).

2. The Claimed Invention Has Been Praised

Praise for the invention is further evidence of the novelty and worth of the inventions. *Corning Glass Works v. Sumitomo Elec.* U.S.A., *Inc.* 671 F. Supp. 1369, 1368, 5 U.S.P.Q.2d 1545, 1569 (S.D.N.Y. 1987) (citing *Rosemount Inc. v. Beckman Instruments, Inc.*, 727 F.2d 1540, 1546, 221 U.S.P.Q. 1, 7 (Fed. Cir 1984), *aff'd*, 868 F.2d 1251, 9 U.S.P.Q.2d 1962 (Fed. Cir. 1989); *see also Polysius Corp. v. Fuller Co.*, 709 F. Supp. 560, 573, 10 U.S.P.Q.2d 1417, 1426 (E.D. Pa.), *aff'd mem.*, 889 F.2d 1100 (Fed. Cir. 1989).

As demonstrate by the evidence attached to the Smith 132 Affidavit and referred to above, the inventors have received great attribution for the invention.

In sum, the objective evidence further establishes the non-obviousness of the invention, as claimed in the present Application.

Therefore, as a result of the foregoing, Applicant respectfully requests that the Examiner withdraw the rejection of Claims 35-44, 46-47 and 50-51 under 35 U.S.C. § 103(a) as obvious over *Ajayan* in view of *Curl*.

IV. INTERVIEW SUMMARY

Attached to the Office Action was an Interview Summary of the June 7, 2006, discussions with the Examiner. As Applicant stated in its Amendment Accompanying Request For Continued Examiner, filed June 30, 2006 (the "June 30, 2006 Amendment"), Applicant greatly appreciated the opportunity to discuss with the Examiner the then Final Office Action and the background technology of the Application. June 30, 2006 Amendment, at 4.

The Examiner concluded the Interview Summary by stating "Applicant will present evidence that will show that the material of 'Growth Morphologies' [*Ajayan*] would not have the

claimed amount of (10,10) single wall carbon nanotubes." Interview Summary, at 3. For completeness, Applicant notes that such evidence was submitted with Applicant's June 30, 2006 Amendment. In the Office Action, the Examiner has indicated that "'Growth Morphologies' [*Ajayan*] differs from the claimed invention because it does not disclose that the nanotubes at [*sic*, are] 10,10 nanotubes." Office Action, at 4. Furthermore, the Examiner indicated in the Office Action, at 4, "Applicant has presented evidence that (10,10) nanotubes are not necessarily present in the claimed amount even if single wall nanotubes having the particularly claimed diameter are formed." *Id.* Therefore, for completeness, Applicant understands that no further presentation of evidence is required on this point and hence, no further evidence is being submitted herewith.

V. CONCLUSION

As a result of the foregoing, it is asserted by Applicant that the Claims in the Application are now in a condition for allowance, and respectfully requests allowance of such Claims. Applicant respectfully requests that the Examiner call Applicant's attorney at the below listed number if the Examiner believes that such a discussion would be helpful in resolving any remaining problems.

Respectfully submitted,

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Carbon nanotubes

In 1991 Iijima Sumio of NEC Corporation's Fundamental Research Laboratory, Tsukuba Science City, Japan, investigated material extracted from solids that grew on the tips of carbon electrodes after being discharged under C_{60} formation conditions. Iijima found that the solids consisted of tiny tubes made up of numerous concentric "graphene" cylinders, each cylinder wall consisting of a sheet of carbon atoms arranged in hexagonal rings. The cylinders usually had closed-off ends and ranged from 2 to 10 micrometres (millionths of a metre) in length and 5 to 40 nanometres (billionths of a metre) in diameter. High-resolution transmission electron microscopy later revealed that these multiwalled carbon nanotubes (MWNTs) are seamless and that the spacings between adjacent layers is about 0.34 nanometre, close to the spacing observed between sheets of graphite. The number of concentric cylinders in a given tube ranged from 3 to 50, and the ends were generally capped by fullerene domes that included pentagonal rings (necessary for closure of the tubes). It was soon shown that single-walled nanotubes (SWNTs) could be produced by this method if a cobalt-nickel catalyst was used. In 1996 a group led by Smalley produced SWNTs in high purity by laser vaporization of carbon impregnated with cobalt and nickel. These nanotubes are essentially elongated fullerenes.

Individual carbon nanotubes may be metallic or semiconducting, depending on the helical orientation of the rows of hexagonal rings in the walls of the tubes. Rather than conducting electricity via electron transport, a diffusive process that results in electron scattering and conductive heating, SWNTs exhibit ballistic transport, a

highly efficient and fast conduction process in which electrons, prevented from diffusing through the wall of the tube or around its circumference by the regular hexagonal array of carbon atoms, propagate rapidly along the axis of the tube. Open-ended SWNTs emit electrons at currents that attain approximately 100 nanoamperes (billionths of an ampere). Owing to such remarkable properties, electrical conductors made of bundles of nanotubes should exhibit zero energy loss. Aligned MWNTs show promise as field-emission devices with potential applications in electronic flat-panel displays. Nanotubes may also be used as highly resilient probe tips for scanning tunneling microscopes and atomic force microscopes.

Carbon nanotubes exhibit faster phonon transport than diamond, which was previously recognized as the best thermal conductor, and the electric current-carrying capacity of nanotubes is approximately four orders of magnitude higher than that of copper. The Young's modulus of MWNTs (a measure of their elasticity, or ability to recover from stretching or compression) is estimated by researchers to be greater than that of carbon fibres by a factor of 5 to 10. MWNTs are capable of readily absorbing loads via a sequence of reversible elastic deformations, such as buckling or kinking, in which the bonds between carbon atoms remain intact.

Nanotubes can be "decapped" by oxidation and the resulting opened tubes filled with metals, such as lead, or even with buckyballs. Boron and nitrogen atoms may be incorporated into carbon nanotube walls. Microscopic metal particles that would otherwise be rapidly oxidized may be stabilized in air by encapsulation in nanotube skins.

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